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THE PROBLEM OF TWO GRAVITATING AND RADIATING BODIES

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1. Problems of Photogravitational Celestial Mechanics,
2. Problem of Two Bodies,
3. Examples of the Application of Results.]

Section 1. Problems of Photogravitational Celestial Mechanics.

The main starting point of classical celestial mechanics is the assumption that the movement of celestial bodies, as free material points, is controlled exclusively by their forces of mutual attraction obeying Newton's law. It is easy to see, however, that this premise is unfulfilled in respect to philosophy and does not correspond to the true character of interaction between bodies.

Actually, if one can admit the existence of a macro-body ideally neutral in respect to electrostatic and magnetic properties, still it is impossible to imagine a body not radiating into space as long as its temperature does not equal absolute zero.

Thus the field of repulsive forces of radiation is as much an irremovable attribute of matter in the macrocosm as its field of gravitational forces, and consequently gravitational interaction between bodies in a pure form can never be realized in nature.

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The tremendous role of repulsion, which [i.e. repulsion] is the "active side of motion", was frequently and persistently emphasized by F. Engels. [1] He wrote: "It is ordinarily assumed that gravity is the most general definition of materiality -- that is, that attraction and not repulsion is the important property of matter. But attraction and repulsion are just as inseparable from each other as positive and negative, and therefore already on the basis of dialectics itself it can be predicted that the true theory of matter must afford repulsion just as important a place as to attraction and that a theory of matter based just on attraction must be deficient ... Everyone acknowledges the materialness of comet tails. They display tremendous repulsion."

From the above-mentioned it follows that the theoretical foundation of celestial mechanics must be a union of the law of universal gravitation with the law of radiant repulsion between bodies; that is, the Newton-Lebedev law of photogravitational interaction, which was established in 1891 by P. N. Lebedev in his work, "Concerning the Repulsive Force of Radiating Bodies" [2]. A dialectical approach to the phenomena, the content of classical celestial mechanics constitutes the consideration of which [i.e. phenomena], permitted the well-known Russian physicist P. P. Lazarev [3] 40 years ago to express this idea in the following words: "All laws of motion of celestial bodies thus will be reduced to two: to the law of universal gravitation and the law of light [radiant] repulsion, and their combination must explain all motions in our solar system."

It is quite indisputable that in the overwhelming majority of problems the quantitative ratio between both forces is such that the character of the motion is determined with sufficient accuracy by the single Newtonian force of attraction. On the other hand, however, it is known that a group of problems of celestial mechanics, whose study require taking the repulsive forces of radiation into account, is also being expanded extremely rapidly, far from being exhausted by those

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partial cases where one of the interacting bodies is the Sun and the other, very small cosmic dust. The influence of repulsive forces turns out to be essential even for significantly larger sizes of bodies, if the effect of the action of these forces bears a cumulative character (for example, secular variation in the orbits of asteroids), or if the density of one of the bodies is sufficiently small (for example, the interaction of a star with a dust nebula), or, finally, if both of the bodies are not too large. For sake of illustration of the last, it is sufficient, for example, to say that two identical black balls with mass 1 gram and volume 1 cm^3 , each at ordinary room temperature, will be repelled from each other in a vacuum with a force which exceeds 100 times the force of their gravitational interaction.

The practical construction of the foundation of photogravitational celestial mechanics is the indisputable work of Russian and Soviet scientists, and above all, of F. A. Bredikhin [4] and S. V. Orlov [5] -- namely, creators of the widely known mechanical theory of cometary forms. Significant contributions to this field were made also: by N. Ye. Zhukovskiy [6], when he obtained the exact formulas governing motion under the Sun's repulsive force; by D. A. Gol'dammer [7], who investigated light [radiant] pressure inside a medium and obtained two years earlier than Poynting [8] the formula for the reactive pressure on a radiating area; by B. Yu. Levin [9], who investigated the pressure of light on small particles in connection with their physical properties and verified Debye's results; by I. F. Polak [10], who indicated an original method for solving the problem of two bodies for the case of repulsive forces; by V. G. Fesenkova [11], who studied the movement of meteoric matter in interplanetary space taking light's pressure into account; by O. Yu. Shmidt [12], who made extensive use of the effect of light [radiant] retardation [Brehm] in his cosmogonical theory; by T. A. Agekyan [13], who developed the theory of photogravitational interaction between (a) clouds of cosmic dust and (b) stars; and by

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many other Russian and Soviet scientists.

The abundance of the accumulated material permits us to acknowledge as opportune and expedient its reduction to a rigorous system by way of a final definitive formulation of photogravitational celestial mechanics as a self-consistent division of astronomy. Here, proceeding from the teachings of Lenin concerning the interaction of theory and practice, we can be confident that the theoretical generalization of individual disconnected investigations arising in the process of solving concrete practical problems will be able to place us on new paths and fields of application of the laws and methods in photogravitational celestial mechanics.

The present work is devoted to an investigation, on the basis of the Newton-Lebedev law, in a more general form than was done in the above-cited and other works, of one of the basic problems of photogravitational celestial mechanics -- namely, the problem of two radiating and gravitating bodies.

[End of Section 1/3]

Section 2. Problem of Two Bodies

Let us consider an isolated system of two spherical absolutely black bodies, whose dimensions exceed the wavelength of the radiation falling on them, assuming the forces of photogravitational interaction between them to be central and neglecting the variations in the masses and temperatures of these bodies.

As is known, a supplementary force arising in consequence of taking motion into account involves, along with the main repulsive force acting on the body which [i.e. body] is at rest in the radiant field, a ratio of order v/c (here v is the velocity of motion, and c is the speed of light). It would be easy to show that the accompanying radiation of mass

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by both bodies for any imaginable assumptions concerning their dimensions, temperatures and time intervals causes such insignificant variations in their forces of gravitational interaction that the error, which we are admitting by determining this force from constant values of the masses, is even several orders less than the repulsive forces acting between them. Thus in the initial approximation we can assume with sufficient accuracy that the motion of the bodies is controlled only by two basic forces: gravitational attraction of masses constant in magnitude, and radiant repulsion corresponding to the relative rest of the radiating bodies.

Let us introduce the following designations: m_1 and m_2 are the masses, r_1 and r_2 are the radii, d_1 and d_2 are the densities, T_1 and T_2 are the absolute temperatures respectively of the first and second bodies, f and R are the force of gravitational interaction and distance between the bodies, p_1 is the force of radiant pressure of the first body on the second body, p_2 that of second body on the first body, F_1 is the force of the resulting action of the first body on the second body, F_2 is that of the second body on the first body, q_1 is the coefficient of reduction of mass of the first body in the sense of its resulting action on the second body, q_2 is that of second on first, $G = 6.67 \cdot 10^{-8}$ cgs is the gravitational constant $\sigma = 5.75 \cdot 10^{-5}$ cgs is the constant of the Stefan-Boltzmann law.

Let us write down the main relations for the forces acting between the bodies:

$$f = G m_1 m_2 \cdot R^{-2}; \quad (1)$$

$$p_1 = f A T_1^4 / r_1 d_1 r_2 d_2, \quad p_2 = f A T_2^4 / r_1 d_1 r_2 d_2 \quad (2)$$

$$(\text{where } A = 9\sigma/16\pi Gc = 5.15 \cdot 10^{-9} \text{ cgs});$$

$$p_1/p_2 = T_1^4 / T_2^4 \quad (3)$$

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From (3) it follows that, for the repulsive forces, action equals reaction only when the temperatures of the radiating bodies are equal.

From (1) and (2) we have

$$p_1/f = AT \frac{4}{r_1 d_1 r_2 d_2}, \quad p_2/f = AT \frac{4}{r_1 d_1 r_2 d_2}; \quad (4)$$

hence we see that the relative magnitude of the repulsive force (in comparison with the gravitational force) depends in identical manner upon the dimensions and densities of both interacting bodies.

For the resulting forces we find:

$$F_1 = f - p_1 = q_1 f, \quad F_2 = f - p_2 = q_2 f, \quad (5)$$

$$\text{where } q_1 = (1 - \Delta q_1) = (1 - AT \frac{4}{r_1 d_1 r_2 d_2}), \quad (6)$$

$$q_2 = (1 - q_2) = (1 - AT \frac{4}{r_1 d_1 r_2 d_2}).$$

As is seen from (6), the coefficients of reduction of masses of the bodies can be equal to zero or possess negative values for sufficiently small magnitude of any of the co-factors entering into the denominator of the second term on the right side of this expression.

The differential equations of motion of the two bodies in the xyz-system can be written thus:

$$\frac{d^2 x_1}{dt^2} = G q_2 m_2 \frac{(x_1 - x_2)}{R}, \quad \frac{d^2 x_2}{dt^2} = G q_1 m_1 \frac{(x_2 - x_1)}{R},$$

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$$\frac{d^2 y_1}{dt^2} = Gq_2 m_2 (y_1 - y_2)/R^3, \quad \frac{d^2 y_2}{dt^2} = Gq_1 m_1 (y_1 - y_2)/R^3, \quad (7)$$

$$\frac{d^2 s_1}{dt^2} = -Gq_2 m_2 (s_1 - s_2)/R^3, \quad \frac{d^2 s_2}{dt^2} = Gq_1 m_1 (s_1 - s_2)/R^3.$$

Multiplying by $q_1 m_1$ and $q_2 m_2$ corresponding by the first and second column of the system of equations (7) and adding them in a line, we get:

$$\left. \begin{aligned} q_1 m_1 \frac{d^2 x_1}{dt^2} + q_2 m_2 \frac{d^2 x_2}{dt^2} &= 0, \\ q_1 m_1 \frac{d^2 y_1}{dt^2} + q_2 m_2 \frac{d^2 y_2}{dt^2} &= 0, \\ q_1 m_1 \frac{d^2 s_1}{dt^2} + q_2 m_2 \frac{d^2 s_2}{dt^2} &= 0. \end{aligned} \right\} \quad (8)$$

We shall use the name "reduced center of inertia of the system of two bodies" for the point determined by the following coordinates:

$$\left. \begin{aligned} x_c &= (q_1 m_1 x_1 + q_2 m_2 x_2)/(q_1 m_1 + q_2 m_2), \\ y_c &= (q_1 m_1 y_1 + q_2 m_2 y_2)/(q_1 m_1 + q_2 m_2), \\ s_c &= (q_1 m_1 s_1 + q_2 m_2 s_2)/(q_1 m_1 + q_2 m_2). \end{aligned} \right\} \quad (9)$$

Obviously, this point lies on the straight line passing through both bodies and divides the segment between them internally (for identical signs of q) or externally (for unlike signs of q) in a ratio inverse to the reduced masses of the bodies. For $q_1 m_1 + q_2 m_2 = 0$, the reduced center of inertia is displaced toward infinity.

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Integrating twice the system (8) and comparing the result with (9), we easily see that the point (x_c, y_c, z_c) will move uniformly and rectilinearly, thus justifying the name of "center of inertia" ascribed to it.

Thus, although only the 'heavy' masses of the bodies are actually reduced, the center of inertia of the system is displaced [shifted] just as though also their inertial masses are reduced.

As for the classical theorem concerning the motion of the center of masses, this theorem is not fulfilled here, which is a direct consequence of the violation of Newton's 3rd law.

Actually, it follows immediately from (5) and (6) that the sum of the internal forces acting on the system, $F_1 - F_2 = (q_1 - q_2) f$, is in the general case not equal to zero. The resultant of these forces always passes through the reduced center of inertia of the system. Therefore the classical center of masses under the action of just single internal forces must move accelerated in a conic section with focus at the reduced center of masses. Similarly, other general theorems governing the dynamics of the system, on a consideration of which [i.e. theorems] we shall not linger here, are also violated.

Let us go on to the solution of our main problem.

The relative acceleration g of body m_2 in the system, which [i.e. system] is connected with body m_1 , will obviously be

$$g = F_1/m_2 + F_2/m_1,$$

or, after a small transformation with the aid of (5) and (1),

$$g = \mu/R^2, \quad (10)$$

$$\text{where } \mu \text{ is } \mu = G(q_1 m_1 + q_2 m_2).$$

(11)

The formal agreement of (10) with the analogous expression in the classical problem permits us to obtain, without derivation of the general Kepler-Newton laws, the energy integral and all other relations connected with them.

Thus we can write:

$$1) \text{ The law of areas: } R^2 \frac{d\phi}{dt} = C \quad (12)$$

where C is a constant of integration, equal to double the sectorial speed.

2) The equation of the trajectory is the polar system (R, ϕ) of coordinates:

$$R = \frac{C^2/\mu}{1 + 2 H C^2/\mu^2 \cdot \cos(\phi - \phi_0)} \quad (13)$$

3) The law governing the dependence between period P and semi-axis a :

$$P^2/a^3 = 4\pi/\mu \quad (14)$$

4) The equation of kinetic energy [vis viva]:

$$v^2 = \mu (2/R - 1/a), \quad (15)$$

and also the expression for the focal parameter (h), total specific energy (H), excentricity (e), major semiaxis (a), and period (P):

$$h = C^2/\mu$$

$$H = \frac{1}{2} v^2 - \mu/R$$

$$e \sqrt{1 + 2 H C^2/\mu^2} = \sqrt{1 + C^2/\mu^2 (v^2 - 2\mu/R)} \quad (16)$$

$$a = \mu / (2\mu R^{-1} - v^2)$$

$$P = 2\pi\mu \cdot (2\mu R^{-1} - v^2)^{-3/2}$$

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As is evident from (12) and (16), the motion will occur with a constant sectorial speed, but less than in the classical case for the same parameter since $\mu G(m_1 - m_2)$.

It follows from (13) and (16) that the trajectory of motion can, depending upon the signs of μ and H , be any conic section, including: the convex (relative to the other body) branch of a hyperbola; a straight line (we are not concerned with the case where the initial velocity is collinear with the forces and where, for any μ and H , the motion will be rectilinear); and a point, corresponding to the relative rest of the body. For various combinations of the signs of μ and H we shall have the following trajectories:

- | | | |
|--------------|-------------------|-------------------------------|
| 1. $\mu > 0$ | a) $H < 0, e < 1$ | : ellipse, |
| | b) $H = 0, e = 1$ | : parabola, |
| | c) $H > 0, e > 1$ | : concave branch of hyperbola |

[Note: we note in passing that only for the last case is it necessary to consider the major semiaxis in expressions (14) and (15) negative.]

- | | | |
|--------------|--------------------------------------|-------------------------------|
| 2. $\mu = 0$ | a) $H < 0, e = \dots$ | : impossible |
| | b) $H = 0, e = \text{indeterminacy}$ | : point |
| | c) $H > 0, e = \infty$ | : straight line |
| 3. $\mu < 0$ | a) $H < 0, e = \dots$ | : impossible |
| | b) $H = 0, e = \dots$ | : impossible |
| | c) $H > 0, e > 1$ | : convex branch of hyperbola. |

It is also necessary to emphasize that, in as much as the sign of each of the coefficients of reduction is not determined by the sign of μ separately, which fact is independent of whether the resulting force acting on a given body is attracting or repelling, a body can move relative to the other body on any conic section, starting from a

circle and ending in the convex branch of a hyperbola.

Finally, from (14) it follows that for a given major semiaxis the period of revolution will be greater than in the classical case since $\mu < G(m_1 + m_2)$.

Up till now we have been considering our problem in a general form. In practice, however, it is often necessary to deal with such dimensions, masses, and temperatures that we can assume, with sufficient accuracy, as follows:

$$m_1 \gg m_2, \quad \Delta g_1 = 1 - g_1 \ll 1, \quad g_1 m_1 \gg g_2 m_2 \quad (17)$$

then the magnitude of μ can be represented thus:

$$\mu = (1 - \Delta g_1) \mu_0 \quad (18)$$

where $\mu_0 = Gm_1$

Substituting this value of μ into expression (12), (13), (14), (15), and (16), we easily obtain all the formulas and laws of the two-body problem as limited by conditions (17).

In order to evaluate how much, in this case, the orbit is deformed under the influence of radiant pressure, let us consider two non-interacting bodies with identical initial conditions of motion, which are revolving around a general third body whose coefficient of reduction of mass for one of them equals unity, but for the other differs from unity by a small quantity Δg . Obviously, the first of these bodies will move along the classical orbit whose elements we designate by the same symbols with the addition of the index zero, and the second body will move along the reduced orbit whose elements we express by means of the classical elements with an accuracy up to terms of the first order

relatively to Δq . With this aim we substitute (18) into (16), and easily find, for given values of v , R , C , the following:

$$h = h_0 (1 + \Delta q), \quad \Delta h = h_0 \Delta q; \quad (19)$$

$$H = H_0 [1 + 2\mu_0 R^{-1} \Delta q / (v^2 - 2\mu_0 R^{-1})], \Delta H = -H_0 2\mu_0 R^{-1} \Delta q \quad (20)$$

$$e = e_0 \left\{ 1 + C^2 v^2 \mu_0^{-2} (1 - \mu_0 R^{-1} v^{-2}) \Delta q \right\}, \quad (21)$$

$$\Delta e = C^2 v^2 \mu_0^{-2} (1 - \mu_0 R^{-1} v^{-2}) \Delta q$$

$$a = a_0 \left\{ 1 + [2\mu_0 R^{-1} / (2\mu_0 R^{-1} v^{-2}) - 1] \Delta q \right\}, \Delta a = a_0 (2\mu_0 R^{-1} v^{-2}) \Delta q \quad (22)$$

$$P = P_0 \left\{ 1 + [3\mu_0 R^{-1} / (2\mu_0 R^{-1} v^{-2}) - 1] \Delta q \right\}, \Delta P = P_0 (3\mu_0 R^{-1} v^{-2}) \Delta q \quad (23)$$

In particular, for a circular orbit of the first body the increments of the elements of the second body's orbit assume the following simple form:

$$\Delta h = a_0 \Delta q$$

$$\Delta e = \Delta q$$

$$\Delta P = 2 P_0 \Delta q$$

$$= 4\pi a_0^{3/2} \mu_0^{-1/2} \Delta q$$

$$\Delta H = \mu_0 a_0^{-1} \Delta q$$

$$\Delta a = a_0 \Delta q \quad (24)$$

In concluding this section, we note that the seeming paradoxicalness of certain derivations obtained above is a consequence of the violation, in our case, of the classical theorem concerning the movement of the center of masses, which is in its turn connected with the fact that we are not considering the mass of the energy radiated by both bodies into their surrounding space. However, the latter is completely justified in as much as for practical purposes we are interested not in the matter

which is going irrevocably to infinity but in the matter which remains in the field our investigation.

End of Section 2/3

Section 3. Examples of the Application of Results

Let us try to evaluate the above-obtained results from the point of view of their possible practical application to the solution of concrete astronomical problems. Here, instead of setting for ourselves the goal of promoting some hypotheses or other, we are limiting ourselves mainly to a consideration of numerical examples in application of the formulas derived in the preceeding section. However, in selecting the original data for these examples we will be led by the tendency to make them as close as possible to definite real problems from the field of cometary astronomy and stellar dynamics.

First of all we turn to expression (4). From it follows that the relative force of radiant pressure (in comparison with gravitational attraction), on the part of any body for a given density of the latter, will be greater the smaller its size. Thus, even for low temperatures, small bodies can be repelled with the same relative force as for example, the Sun.

Let us calculate according to (4) the diameter d of two identical balls for which [i.e. diameter] and the lesser of which their resulting interaction will be repulsive, assuming that the temperatures of both balls is completely determined by their distance R from the Sun from the familiar formula:

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$$T = 277/\sqrt{R}. \quad (25)$$

Setting $p/f = 1$ in (4) and using (25), we easily find:

$$(\text{diameter}) d = 11/R\delta \text{ cm}, \quad (26)$$

where R is in astronomical units and δ is density in gram/cm^3 .

For $\delta = 2.75 \text{ gram/cm}^3$, we have:

$$(\text{diameter}) d = 4/R \text{ cm}. \quad (27)$$

From (27) it follows that, for example, at the distance of Pluto small balls having diameters $d \leq 0.1 \text{ cm}$ will repel each other; and at a distance of the Earth, we have $d \leq 4 \text{ cm}$; and at a distance of Mercury, $d \leq 10 \text{ cm}$.

We will call absolutely unstable that system of material points inside of which only repulsive resulting forces act.

Then on the basis of (27) we can assert that, on the orbit of the comet Enke, every cluster of black sphericles not screening each other, and with the above-assumed density and with diameters about 1 cm and less, will be absolutely unstable. The latter fact compels us to acknowledge Plummer's hypothesis [14] as being completely inconsistent, which hypothesis attempted, as is well known, to explain the exceleration of comet Enke as due to the heliocentric effect of Poynting-Robertson. To do this it was necessary for Plummer to assume that the nucleus of the comet consists of particles, not screened from each other, with diameters about $4 \cdot 10^{-3} \text{ cm}$. Moreover, such particles, even at the aphelion of the comet, must be repelled from each other with a force which exceeds about 50,000 times their force of gravitational interaction.

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We note, by the way, that for the dimensions of the particles assumed by Plummer the effect of diffraction cannot even be professed, inspite of the increase, according to Wien's law, of the wavelength of their own radiation.

A cluster of spheres with diameters half a meter and less which [i.e. cluster] moves in an orbit with perihelic distance about 0.1 astronomical unit also becomes absolutely unstable as it approaches the perihelion. Here it is necessary to emphasize that the deviation of meteorites from a sperical form can only increase their relative surface and consequently heighten the effect of radiant pressure among them.

Relying on the same formula (4) together with (26), we easily convince ourselves that, for an asteriod with a diameter of 140 meters and density equal to the Sun's density, the ratio P/f will, for temperature $T = 45^{\circ}\text{K}$ (at the distance of Pluto), be 30 times less, but for $T = 450^{\circ}\text{K}$ (at the distance of Mercury), 330 times greater, than for the Sun. Hence it follows that the differential equations of the movement of small particles in the field of a comet's nucleus which [equations] have not been set up with consideration for its repulsive forces cannot suggest the behavior, even if this nucleus consists of rather coarse lumps.

In the previous computation we proceeded from the assumption that the repulsive forces of an asteriod are completely determined by its radiation. It must be practically so if we consider that the albedo of an asteroid is around 10%. In this case the average power of its radiation must almost exceed by 10 times the power of reflection of the Sun's rays.

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Returning to formula (4), we note that for a given mass of a spherical body the density decreases, with increase in its radius, proportionally to the cube of the linear dimensions of the body. Therefore, even if the mass of the body should never ^e be large, for sufficiently large dimensions the body will be repelled by any other body more strongly than it is attracted (if, of course, the body has not practically lost its absorptive properties). In practice these conditions are realized when the interacting bodies are a star and dark nebula.

In actuality, if we proceed from present evaluations $\sqrt{15}$ of mass, size and optical thickness of dark nebulas, then it should be easy to show that the repulsive force acting on a nebula on the part of a star must be of one order with the force of gravitational interaction between them. Thus, for example, a spherical ^b nebula with a radius about 2.7 parsecs and mass equal to the Sun's mass will be, for an average, over the entire disk, optical thickness of $0^m.25$ (that is, the absorbing radiation is 20% of the radiation falling on it), absolutely repelled by the Sun with the same force with which the Sun attracts it. For these two bodies the equation $m\mu/\mu = 0$ will hold, and in the case of zero initial velocity of both bodies they must remain at relative rest, although as a whole the entire system will be moving accelerated in a direction from the Sun toward the nebula.

Thus the theorem concerning the movement of the center of masses and also the exact formulas (11) and (16) can, possibly, be utilized in a study of the motion of stars close to clouds of cosmic dust.

Within the limits of the Solar system, greatest interest is represented by the case of two bodies (Sun-meteorite) satisfying condition (17).

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Let us consider the heliocentric movement of two non-interacting spherical bodies, one of which is a meteorite with diameter 1 cm and density equal to the Sun's density ($\Delta \rho = 10^{-7}$), and the other is an asteroid with mass $m = 10^{14}$ grams (the order of mass of a comet nucleus) moving in a classical circular orbit with radius 1 astronomical unit. Let the meteorite have at the initial moment the same velocity and position as the asteroid. Obviously, the initial position must correspond to the perihelion of the meteorite's orbit. Substituting all the data in (24), we conclude as follows:

- 1) the specific energy of the meteorite will, at 10^9 ergs/gram, exceed the specific energy of the asteroid;
- 2) the major axis of the meteorite's orbit will, at 30,000 km, be greater than the diameter of the asteroid's orbit;
- 3) the period of revolution of the meteorite will, at 1 hour 40 minutes, be greater than that of the asteroid; and consequently even after the first revolution the meteorite will be 180,000 km from the asteroid, and after 2500 years it will be at the opposite point of its orbit.

Still more rapidly, as can be seen from (19)-(23), will occur the disintegration of a system moving in an elliptic orbit, under the condition that it begin close to perihelion. Thus, for example, if these two bodies leave simultaneously the perihelion of the asteroid's classical orbit with parameters $e = 0.98$ and $a = 100$ astronomical units, then the meteorite will lag, in the next succeeding return to perihelion, 15 years behind the asteroid or lag about $5 \cdot 10^9$ km behind the asteroid.

Until now we have considered that both bodies do not interact with each other. In this connection we note that the radiant pressure on a meteorite on the part of the Sun will be 10 times greater than the gravitational

attraction of the meteorite towards the asteroid under the condition that the distance between the latter is $\rho \geq 400$ at Pluto's orbit or $\rho \geq 4$ km at Mercury's orbit. From this example it is clear that the gravitational interaction between the discussed bodies, especially if we take into consideration the fact that this interaction is weakened by their own natural radiation, can play only an insignificant role in the ^eprevention of the system's disintegration. On the other hand, it follows from this that the decay of the system close to perihelion not only gives a maximum effect in the sense of variations in the orbit's elements but also is realized significantly more easily.

In conclusion the author expresses his gratitude to L. A. Chernov for his advice and for his attentive review of the present work.

[End of Section 3/3]

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[Note: GITTL - State Publishing House of Technical Theoretical Literature
 GTTI - State Technical-Theoretical Press
 ONTI - All-Union Scientific Technical Press
 OGIZ - All-Union Publishing House.]

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